

Creating an Emission Inventory for Modeling Global Climate Change Effects on Regional Air Quality

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Outline

Context: EPA Global Climate Research Program

- ♦ **Purpose: Need for future year inventories**
- ♦ **Approach: Proposed methods for creating modeling inventories for 2050**
- ♦ **Implementation plan**

Context: EPA Global Climate Research Program (GCRP)

Potential effects of climate change documented, including changes in meteorology that affect air quality by:

- ◆ **Altering chemical reactions and transport**
- ◆ **Modifying anthropogenic emissions, including adaptive responses (e.g., fuel changes, climate-related changes in land use patterns)**
- ◆ **Changing emissions from biogenic sources**
- ◆ **In addition, changes in land use can affect emissions and feed back to affect climate**

EPA GCRP Framework

Assessment of climate change effects between now and 2050 on regional (~36km resolution) air quality includes:

- ♦ **Analysis of meteorological and air quality data to identify trends and correlations**
- ♦ **Modeling to simulate relations between global and regional meteorology, emission, and air quality components**

Global Change Scenarios

Global Emissions

Global Air
Quality

Global
Meteorology

Global

Regional Change
Scenarios

Regional Boundary
Climates

Regional
Meteorology

Regional
Emissions

Regional

Regional Air Quality

EPA GCRP Framework (2)

Down-scaling to regional level, using:

- ♦ **Information from a Global Climate Model (GCM) and Global Chemical Transport Model (GCTM) to provide global climate drivers and boundary conditions for regional meteorology and air quality**
- ♦ **The fifth generation Penn State/NCAR Mesoscale Model (MM5) for regional climate**
- ♦ **The EPA Community Multi-scale Air Quality (CMAQ) model for regional simulations**

EPA GCRP Framework (3)

Incremental Analyses will include:

- ♦ **Simulations of regional air quality in 2050 based on climate change and current emission scenarios, to isolate effects of climate change**
- ♦ **Simulations of regional air quality in 2050 based on changes in meteorology and projected emissions, not considering technology changes**
- ♦ **Simulations of regional air quality in 2050 based on changes in meteorology and projected emissions, included changes in technology**

Future Year Emission Inventory Needs for Evaluating Climate Effects

Data used by EPA for emission modeling using the SMOKE system, to be projected to 2050 for a range of scenarios, including:

- **Projection of emissions at the SIC level**
- **Accounting for changes in technology, with emphasis on electrical generation and mobile sources**
- **Changes in land cover (vegetation), that in turn affect the spatial patterns of biogenic emissions**
- **Changes in land use patterns, affecting patterns of anthropogenic emissions.**

Future Year Emission Inventory Needs (2)

- ♦ **Because the modeling domain covers much of North America, projected emissions are needed for Canada and Mexico.**
- ♦ **Less detailed emission information for Canada and Mexico will require approximated projections, possibly scaled from IPCC Special Report on Emission Scenarios (SRES) figures**

Future Emission Scenario Approach

- ◆ **Projection of current (possibly 1999) United States emissions to 2050, possibly using the Economic Growth and Analysis (EGAS) system**
 - EGAS is based on Regional Economic Modeling, Inc (REMI) model projections
 - EGAS would need extension through 2050
- ◆ **Mobile source emission factors based on the Mobile 6 model require extension through 2050**
 - Mobile source emission factors need extension to 2050
 - Vehicle type distribution data to come from technology change research (using MARKAL model)

Future Emission Scenario Approach (2)

- ♦ **Technology changes will be included by:**
 - **Incorporating technology change research on electrical power generation and transportation applied in the MARKAL energy-technology-economic framework**
 - **Using changes for other source categories implicit in EGAS projections**
- ♦ **Demographic shifts will be taken from U.S. Census projections. Mid-level Census and IPCC SRES projections are similar**

U.S. Population Projections: 2000, 2025, 2050 (in millions)

	2000	2025	2050
SRES Scenarios			
? A1, B1	277	336	383
? A2	278	349	417
? B2	278	332	348
Census - Middle Projection	275	338	404
Census 2000 Estimate	281		

Future Emission Scenario Approach (3)

- ◆ **Biogenic emissions and changes in plant physiology and species composition**
 - **Effects of temperature change on biogenic emission factors may be small**
 - **Emphasis will be on changes in emission from climate changes related to moisture stress and relative humidity**
 - **Future spatial changes of natural vegetation reflecting climate change tentatively will be addressed using results from the Mapped Atmosphere Plant-Soil System Model, which was also used by IPCC**

Future Emission Scenario Approach (4)

- ◆ **Chemical species, spatial, and temporal allocation procedures**
 - Little change in chemical speciation profiles for source emissions is assumed
 - Temporal allocation profiles are assumed to change little by 2050. Some reassignment of source categories to temporal profiles may be needed
 - New high-resolution (4km) spatial surrogates (~60 surrogates) designed for current use will be applied because of resource limits on projecting them. However, many surrogates are related to population and land use, which will be projected separately.

Emission Plan Implementation

♦ Challenges

- Projection of emission inventory components
- Maintenance of consistency between components

♦ Implementation steps

- Specification of climate change bounding scenarios (e.g., conservative, mid-range, and large changes)
- Consistent projection of land use and economic change scenarios
- Application of technological change scenarios for electrical generation and transportation from MARKAL consistently with EGAS projections

Emission Plan Implementation (2)

- ◆ **Implementation steps (2)**
 - Projection of land use to 2050 using consistent demographic and economic assumptions
 - Use of the projected emission scenarios in the SMOKE emission model
 - Use of SMOKE emission model outputs in CMAQ to generate regional air quality results
 - Analysis of regional air quality scenario results
- ◆ **Modification of procedures to reflect new research results (including those from the EPA Science to Achieve Results (STAR) program**

Emission Plan Implementation (3)

- ◆ **Tentative schedule**
 - **Initial analysis report in 2007, reflecting future (2050) air quality without technological changes**
 - **Final analysis report in 2010, reflecting projected emission scenarios including technological change**